

QD
41
A316
1994
gr.11-12
CURRGDHT



EX LIBRIS
UNIVERSITATIS
ALBERTÆNSIS

Chemistry 20-30

Program of Studies

Curriculum Standards Branch
Interim
May 31, 1994

Alberta
EDUCATION

SCIENCE

VISION STATEMENT: SENIOR HIGH SCIENCE PROGRAMS

The senior high science programs will help all students attain the scientific awareness needed to function as effective members of society. Students will be able to pursue further studies and careers in science, and come to a better understanding of themselves and the world around them. The same framework was used for the development of all the senior high science programs, including Science 10, Biology 20–30, Chemistry 20–30, Physics 20–30 and Science 20–30. The expected student knowledge, skills and attitudes are approached from a common philosophical position in each science course.

In the senior high science programs, students focus on learning the big interconnecting ideas and principles. These ideas, or major themes, originate from science knowledge that transcends and unifies the natural science disciplines. These themes include change, diversity, energy, equilibrium, matter and systems; the process by which scientific knowledge is developed, including the role of experimental evidence; and the connections among science, technology and society. In addition to forming a framework for the curriculum, these ideas provide continuity with the junior high program and build on students' previous learning.

The senior high science programs place an increased emphasis on developing methods of inquiry that characterize the study of science. For example, students will further their ability to ask questions, investigate and experiment;

gather, analyze and assess scientific information; and test scientific principles and their applications. They will develop their problem-solving ability and use technology. By providing students with opportunities to develop and apply these skills, they will better understand the knowledge they have acquired.

Students will be expected to show an appreciation for the roles of science and technology in understanding nature. They will possess enthusiasm and positive attitudes toward science and maintain a lifelong interest in science.

The learning context is an integral part of the senior high science programs. It will foster the expected attitudes in students, further the development of students' skills and increase students' understanding of science knowledge, science process, and the connections among science, technology and society. The context for learning will be relevant so students will experience science as interesting and dynamic. Learning opportunities will be made meaningful by providing concrete experiences that students can relate to their world.

The senior high science programs place students at the centre. Students are active learners and will assume increased responsibility for their learning. They will appreciate the value of teamwork and make a positive contribution when working with others to solve problems and complete tasks.



Digitized by the Internet Archive
in 2015

<https://archive.org/details/chemistry2030pro00albe>

CHEMISTRY 20-30

A. PROGRAM RATIONALE AND PHILOSOPHY

Chemistry is the study of matter and its changes. Through the study of chemistry, learners are given an opportunity to explore and understand the natural world and to become aware of the profound influence of chemistry in their lives. Learning is facilitated by relating the study of chemistry to what the learners already know, deem personally useful and consider relevant. Learning proceeds best when it originates from a base of concrete experiences presenting an authentic view of science in the context of chemistry. In Chemistry 20-30, students learn chemistry in relevant contexts and engage in meaningful activities. This facilitates the transfer of knowledge to new contexts. Students are encouraged to participate in lifelong learning about chemistry and to appreciate it as a scientific endeavour with practical impact on their own lives and on society as a whole.

Chemistry, as with all sciences, is an experimental discipline requiring creativity and imagination. Methods of inquiry characterize its study. In Chemistry 20-30, students further develop their ability to ask questions, investigate and experiment; to gather, analyze and assess scientific information; and to test scientific laws and principles and their applications. In the process, students exercise their creativity and develop their critical thinking skills. Through experimentation, problem-solving activities and independent study, students develop an understanding of the processes by which scientific knowledge evolves.

The Chemistry 20-30 program places students at the centre. Students are active learners and will assume increased responsibility for their learning as they work through the program. A thorough study of chemistry is required to give students an understanding that encourages them to make appropriate applications of scientific concepts to their daily lives and prepares them for future studies in chemistry. Students are expected to participate actively in their own learning. An emphasis on the key concepts and principles of chemistry provides students with a more unified view of the sciences and a greater awareness of the connections among them.

These science learnings will take varying amounts of time to acquire, depending on the individual learning styles and abilities of students. While the course is designed for approximately 125 hours, instructional time can be modified to meet the individual needs of students. Some students will require more than 125 hours, while others will require less.

GOALS

The major goals of the Chemistry 20-30 program are:

- to develop in students an understanding of the interconnecting ideas and principles that transcend and unify the natural science disciplines

- to provide students with an enhanced understanding of the scientific world view, inquiry and enterprise
- to help students attain the level of scientific awareness essential for all citizens in a scientifically literate society
- to help students make informed decisions about further studies and careers in science
- to provide students with opportunities for acquiring knowledge, skills and attitudes that contribute to personal development.

Chemistry 20-30 is an academic program that helps students better understand and apply fundamental concepts and skills. The focus is on helping students understand the chemistry principles behind the natural events they experience and the technology they use in their daily lives. The program encourages enthusiasm for the scientific enterprise and develops positive attitudes about chemistry as an interesting human activity with personal meaning. It develops in students the knowledge, skills and attitudes to help them become capable of, and committed to, setting goals, making informed choices and acting in ways that will improve their own lives and life in their communities.

B. GENERAL LEARNER EXPECTATIONS

The general learner expectations outline the many facets of scientific awareness and serve as the foundation for the specific learner expectations covered in section C. The general learner expectations are developed in two categories: *program* expectations and *course* expectations.

PROGRAM GENERAL LEARNER EXPECTATIONS

The *program* general learner expectations are broad statements of science attitudes, knowledge, skills and science, technology and society (STS) connections that students are expected to achieve in all of the senior high school science programs. These *program* general learner expectations are further refined through the *course* general learner expectations and then developed in specific detail through the study of individual units in each of Chemistry 20 and Chemistry 30. All expectations follow a progression from Science 10 through to Chemistry 30, and though listed separately, are meant to be developed in conjunction with one another, within a context.

ATTITUDES

Students will be encouraged to develop:

- enthusiasm for, and a continuing interest in, science
- affective attributes of scientists at work; such as, respect for evidence, tolerance of uncertainty, intellectual honesty, creativity, perseverance, cooperation, curiosity and a desire to understand
- positive attitudes toward scientific skills involving mathematics, problem solving and process skills
- open-mindedness and respect for the points of view of others
- sensitivity to the living and nonliving environment

- appreciation of the roles of science and technology in our understanding of the natural world.

KNOWLEDGE

Science Themes

Students will be expected to demonstrate an understanding of themes that transcend the discipline boundaries, and show the unity among the natural sciences, including:

- **Change:** how all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled
- **Diversity:** the array of living and nonliving forms of matter and the procedures used to understand, classify and distinguish those forms on the basis of recurring patterns
- **Energy:** the capacity for doing work that drives much of what takes place in the Universe through its variety of interconvertible forms
- **Equilibrium:** the state in which opposing forces or processes balance in a static or dynamic way
- **Matter:** the constituent parts, and the variety of states of the material in the physical world
- **Systems:** the interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

SKILLS

Students will be expected to develop an ability to use thinking processes associated with the practice of science for understanding and exploring natural phenomena, problem solving and decision making. Students will also be expected to use teamwork, respect the points of view of others, make reasonable compromises, contribute ideas and effort, and lead when appropriate to achieve the best results. These processes involve many skills that are to be developed within the context of the program content.

The skills framework presented here assumes that thinking processes often begin with an unresolved problem or issue, or an unanswered question. The problem, issue or question is usually defined and hypotheses formulated before information gathering can begin. At certain points in the process, the information needs to be organized and analyzed. Additional ideas may be generated—for example, by prediction or inference—and these new ideas, when incorporated into previous learning, can create a new knowledge structure. Eventually, an outcome, such as a solution, an answer or a decision is reached. Finally, criteria are established to judge ideas and information in order to assess both the problem-solving process and its outcomes.

The following skills are not intended to be developed sequentially or separately. Effective thinking appears to be nonlinear and recursive. Students should be able to access skills and strategies flexibly; select and use a skill, process or technology that is appropriate to the task; and monitor, modify or replace it with a more effective strategy.

● Initiating and Planning

- identify and clearly state the problem or issue to be investigated
- differentiate between relevant and irrelevant data or information
- assemble and record background information
- identify all variables and controls
- identify materials and apparatus required

- formulate questions, hypotheses and/or predictions to guide research
- design and/or describe a plan for research, or to solve a problem
- prepare required observation charts or diagrams, and carry out preliminary calculations

● Collecting and Recording

- carry out the procedure and modify, if necessary
- organize and correctly use apparatus and materials to collect reliable data
- observe, gather and record data or information accurately according to safety regulations; e.g., Workplace Hazardous Materials Information System (WHMIS), and environmental considerations

● Organizing and Communicating

- organize and present data (themes, groups, tables, graphs, flow charts and Venn diagrams) in a concise and effective form
- communicate data more effectively, using mathematical and statistical calculations, where necessary
- express measured and calculated quantities to the appropriate number of significant digits, using SI notation for all quantities
- communicate findings of investigations in a clearly written report

● Analyzing

- analyze data or information for trends, patterns, relationships, reliability and accuracy
- identify and discuss sources of error and their affect on results
- identify assumptions, attributes, biases, claims or reasons
- identify main ideas

● Connecting, Synthesizing and Integrating

- predict from data or information, and determine whether or not these data verify or falsify the hypothesis and/or prediction

- formulate further testable hypotheses supported by the knowledge and understanding generated
 - identify further problems or issues to be investigated
 - identify alternative courses of action, experimental designs, and solutions to problems for consideration
 - propose and explain interpretations or conclusions
 - develop theoretical explanations
 - relate the data or information to laws, principles, models or theories identified in background information
 - propose solutions to a problem being investigated
 - summarize and communicate findings
 - decide on a course of action
- Evaluating the Process or Outcomes
 - establish criteria to judge data or information
 - consider consequences and biases, assumptions and perspectives
 - identify limitations of the data or information, and interpretations or conclusions, as a result of the experimental/research/project/design process or method used
 - evaluate and suggest alternatives and consider improvements to the experimental technique and design, the decision-making or the problem-solving process
 - evaluate and assess ideas, information and alternatives
- the central role of evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
 - the inability of science to provide complete answers to all questions
 - the functioning of products or processes based on scientific principles
 - the ways in which science advances technology and technology advances science
 - the use of technology to solve practical problems
 - the limitations of scientific knowledge and technology
 - the influence of the needs, interests and financial support of society on scientific and technological research
 - the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

FURTHER READING

For a more detailed discussion on how to integrate thinking and research skills into the science classroom, refer to the Alberta Education publications: *Teaching Thinking: Enhancing Learning*, 1990 and *Focus on Research: A Guide to Developing Students' Research Skills*, 1990.

For further reading on integrating science, technology and society into the classroom, refer to the Alberta Education publication: *STS Science Education: Unifying the Goals of Science Education*, 1990.

CONNECTIONS AMONG SCIENCE, TECHNOLOGY AND SOCIETY

Science, Technology and Society (STS)

Students will be expected to demonstrate an understanding of the processes by which scientific knowledge is developed, and of the interrelationships among science, technology and society, including:

COURSE GENERAL LEARNER EXPECTATIONS

The *course* general learner expectations are specific to each of Chemistry 20 and Chemistry 30 providing a bridge between the *program* general learner expectations and the specific learner expectations for each unit of study.

The attitudes expectations refer to those predispositions that are to be fostered in

students. These expectations encompass attitudes toward science, the role of science and technology, and the contributions of science and technology toward society. The knowledge expectations are the major chemistry concepts in each course. The skills expectations refer to the thinking processes and abilities associated with the practice of science, including understanding and exploring natural phenomena, and problem solving. The connections among science, technology and society expectations focus on the processes by which scientific knowledge is developed and on the interrelationships among science, technology and society.

The last *course* expectation links together the study of chemistry, careers, everyday life and subsequent studies.

Although itemized separately, the attitudes, knowledge, skills and STS connections are meant to be developed together within one or more of the contexts listed.

Chemistry 20–30

Attitudes

Students will be encouraged to:

- appreciate the role of empirical evidence and models in science, and accept the uncertainty in explanations and interpretations of observed phenomena
- value the curiosity, openness to new ideas, creativity, perseverance and cooperative hard work required of scientists, and strive to develop these same personal characteristics
- appreciate the role of science and technology in advancing our understanding of the natural world, be open-minded and respectful of other points of view when evaluating scientific information and its applications, and appreciate that the application of science and technology by humankind can have both beneficial and harmful effects and can cause ethical dilemmas
- show a continuing interest in science, appreciate the need for computational competence, problem-solving and process skills when doing science, and value accuracy and honesty when communicating the results of problems and investigations
- value the need for handling, storing and disposing of chemicals and materials safely and with care for the environment.

Chemistry 20

Students will be able to:

Knowledge

- apply the principles of energy and matter conservation to chemical systems undergoing change; and use direct evidence and generalizations to predict the outcomes of chemical change; and relate the principles of chemical change to a variety of applications of reactions
- analyze physical, chemical and biological systems in terms of energy and matter forms, transfers, movement and conservation
- explain the interrelationship between energy and chemical changes to matter and how energy is either released or absorbed as chemical bonds are rearranged and new substances are formed; and describe the practical applications of exothermic and endothermic changes
- explain chemical changes to matter; and write balanced chemical equations to describe transformations and analyze them, quantitatively and qualitatively, to make predictions about the products formed or reactants consumed; and apply this knowledge to stoichiometric calculations in a variety of everyday and industrial situations
- describe solution systems, including acids, bases and gases, quantitatively and qualitatively, and relate their properties to their uses

- describe the diverse forms of matter, using models to illustrate bonding and structure, and using theories to explain the properties and behaviour of a variety of elements and organic and inorganic compounds and solutions, including acids, bases and gases

Skills

- perform investigations and tasks of their own and others' design that have a few variables and yield direct or indirect evidence; and provide explanations based upon scientific theories and concepts
- collect, verify and organize data into tables of their own design, and graphs and diagrams of others' design, using written and symbolic forms; and describe findings or relationships, using scientific vocabulary, notation, theories and models
- analyze and interpret data that yield straight- and curved-line graphs; and use appropriate SI notation, fundamental and derived units, and formulas; and derive from graphs mathematical relationships among variables
- use mathematical language of ratio and proportion, numerical and algebraic methods, gravimetric and solution stoichiometry and unit analysis to solve single- and multi-step problems; and communicate scientific relationships and concepts

Connections Among Science, Technology and Society

- apply cause and effect reasoning to formulate simple relationships for a given instance in which scientific evidence shapes or refutes a theory; and describe the limitations of science and technology in answering all questions and solving all problems, using appropriate and relevant examples
- describe and explain the design and function of technological solutions to practical problems, using scientific principles; and relate the ways in which chemistry and

technology advance one another, using appropriate and relevant examples

- explain for a given instance how science and technology are influenced and supported by society, and the responsibility of society, through chemistry and technology, to protect the environment and use natural resources wisely
- identify subject-related careers and apply the skills and knowledge acquired in Chemistry 20 to everyday life and to related and new concepts in subsequent studies of chemistry.

Chemistry 30

Students will be able to:

Knowledge

- apply the principles of energy and matter conservation to chemical systems undergoing change; and use direct and indirect evidence and theoretical knowledge to predict the outcomes of chemical change; and relate the principles of chemical change to a broad range of applications of reactions
- analyze and evaluate physical, chemical and biological systems in terms of energy and matter forms, transfers, movement and conservation
- explain the interrelationship between energy and physical, chemical and nuclear changes to matter by describing how the rearrangement of bonds results in the release or absorption of energy; and evaluate society's production and use of energy from fossil fuels and nuclear fission
- analyze and explain, quantitatively and qualitatively, the transfer of electrons, and the matter and energy transformations that take place in electrochemical systems; and write balanced oxidation-reduction equations; and describe applications of oxidation-reduction reactions in electrochemical and electrolytic cells

- describe chemical equilibrium systems for acids, bases and gases, quantitatively and qualitatively, and describe some applications
- explain the Brønsted–Lowry concept of acids and bases; and quantitatively and qualitatively, describe acid and base solutions in a variety of ways; and write and analyze reaction equations; and perform calculations and interpretations from titration data
- describe and evaluate the design and function of technological solutions to practical problems, using scientific principles or theories; and relate the ways in which chemistry and technology advance one another, using appropriate and relevant examples
- explain and evaluate for a given instance, and from a variety of given perspectives, how science and technology are influenced and supported by society; and assess the ability and responsibility of society, through chemistry and technology, to protect the environment and use natural resources wisely

Skills

- perform and evaluate investigations and tasks of their own and others' design that have multiple variables and yield direct or indirect evidence; and provide explanations and interpretations, using scientific theories and concepts
- collect, verify and organize data into tables, graphs and diagrams of their own design, using written and symbolic forms; and describe findings or relationships and make predictions, using scientific vocabulary, notation, theories and models
- analyze, interpret and evaluate data that yield straight- and curved-line graphs; and use appropriate SI notation, fundamental and derived units, and formulas; and derive from graphs mathematical relationships among variables
- use mathematical language of ratio and proportion, numerical and algebraic methods, and unit analysis to solve multi-step, nonroutine problems; and communicate scientific relationships and concepts
- identify subject-related careers and apply the skills and knowledge acquired in Chemistry 30 to everyday life and to related and new concepts in post-secondary studies of chemistry.

Connections Among Science, Technology and Society

- apply cause and effect reasoning to formulate relationships for a range of instances in which scientific evidence shapes or refutes a theory; and explain the limitations of science and technology in answering all questions and solving all problems, using appropriate and relevant examples

C. SPECIFIC LEARNER EXPECTATIONS

LEARNING CYCLE

The specific learner expectations consist of the knowledge, skills and attitudes that are to be addressed in Chemistry 20–30. The use of the learning cycle allows students to progress from:

- an introduction framing the lesson in an STS connection relevant to the lives of the learners, and makes connections between past and present learning experiences, as well as anticipates activities to focus students' thinking on the learning outcomes of the activity, to
- the experiential exploration of new content that provides students with a common base of experiences within which they identify and develop key concepts, processes and skills, through
- a hypothesis-building phase where concepts are developed to describe a particular aspect of their experiential exploration, and opportunities are provided to communicate their conceptual understanding, or demonstrate their skills or behaviours, to
- an elaboration phase that extends understanding of key concepts and allows further opportunities to practise desired skills and problem-solving strategies, to
- an application phase where the hypotheses, vocabulary and patterns previously developed are applied to new situations and related to key concepts and principles of science, to
- a final evaluation of the significance of the new learning in an STS context to assess their understanding and abilities, and provide opportunities for teachers to evaluate student progress toward achieving the curriculum standards.

In chemistry, students examine phenomena in a variety of topics to show the relationships among the sciences. Wherever possible, examples

should be framed in the context of the learners' own experiences to enable them to make the connections between scientific knowledge and the society around them, the technology that societies have developed, and the nature of science itself.

PROGRAM OVERVIEW

The Chemistry 20–30 program emphasizes the science themes: *change, diversity, energy, equilibrium, matter* and *systems* as they relate to chemistry. These themes provide a means of showing the connections among the units of study in both courses of the program, and provide a framework for teachers to show students how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of fundamental science concepts and principles, Chemistry 20–30 has the goal of educating students about the nature of science and technology, and the interaction between chemistry and technology. Students must be aware of the tremendous impact of chemistry and associated technology on society, but at the same time they must be aware of the roles and limitations of the chemistry sciences, sciences in general, and of technology in problem solving in a societal context.

CHEMISTRY 20

Chemical *change* and *matter* are the themes common to all the units in Chemistry 20. An understanding of the nature of *matter* and an analysis of its *changes* is essential for understanding what is happening and for predicting what will happen; control of *change* is essential for the design of technological *systems*. The principles of conservation of mass and *energy* help to predict and explain the *changes* that occur in a closed *system*. Chemistry 20 students are developmentally ready to begin defining *matter* in conceptual terms. Observations that provide evidence to support

theories are stressed through experimentation, and linking empirical and theoretical knowledge.

The major concepts allow connections to be drawn among the four units of the course and among all seven units in the two courses in the program.

Chemistry 20 consists of four units of study:

- Unit 1: Matter as Solutions, Acids, Bases and Gases
- Unit 2: Quantitative Relationships in Chemical Changes
- Unit 3: Chemical Bonding in Matter
- Unit 4: The Diversity of Matter: An Introduction to Organic Chemistry.

Each unit in Chemistry 20 uses a different context to investigate the nature of *matter*; to identify common patterns and the processes by which *matter* and *systems* are modified. Unit 1 focuses on the nature of *matter*, specifically solutions and gases, by examining their properties, identifying patterns and analyzing *changes*. In Unit 2, the quantitative relationships in chemical reactions are explored in predicting masses of substances reacted or produced as a result of chemical *change*. In Unit 3, models of the atom are extended to models of bonding as the properties of *matter* and theoretical explanations about its behaviour are linked. In Unit 4, organic compounds are investigated and compared with inorganic *matter*. *Change* as it relates to chemical reactions of organic compounds in living and nonliving systems is also examined.

CHEMISTRY 30

The themes of *change*, *energy* and *systems* are central in Chemistry 30. *Equilibrium* and *matter* are subordinate themes that are also addressed. The components of a *system*, which may be a collection of substances or processes, influence each other by the transfer of *energy* and *matter*. Changes to one part result in *changes* to other parts of the system. In a system at *equilibrium*, opposing reactions are balanced.

The major concepts allow connections to be drawn among the three units of the course and among all seven units in the two courses in the program.

Chemistry 30 consists of three units of study:

- Unit 1: Thermochemical Changes
- Unit 2: Electrochemical Changes
- Unit 3: Equilibrium, Acids and Bases in Chemical Changes.

Chemistry 30 expands upon the concepts and skills introduced in Science 10 and Chemistry 20. Each unit in Chemistry 30 uses a different context to investigate the nature of chemical *change*. The themes are addressed using examples from inorganic and organic chemistry to emphasize the unity of science. *Energy*, as it relates to chemical *change*, is the focus of Unit 1. *Energy* in the form of heat is most commonly absorbed or released in chemical reactions. Thermochemistry is the study of these heat *changes*. *Changes* in physical and nuclear *systems* are briefly explored for comparison. In Unit 2, electrochemical *systems* are examined, oxidation-reduction reactions are analyzed, and the *energy* and *matter* involved are quantified. In Unit 3, the focus is on chemical *systems* at *equilibrium*. Few chemical reactions proceed in only one direction; most are somewhat reversible. Chemical *systems* involving acids and bases are studied as examples.

CHEMISTRY 20

UNIT 1 MATTER AS SOLUTIONS, ACIDS, BASES AND GASES

OVERVIEW

Science Themes: *Change, Matter and Systems*

In Unit 1, students gain an insight into the nature of *matter* through an investigation of *change* in the context of solutions, including acids, bases and gases. Viewing models of *matter* as *systems* undergoing *change* aids in their understanding of the underlying structure of *matter*.

This unit builds on Science 7, Unit 4: Temperature and Heat Measurement; Science 8, Unit 1: Solutions and Substances; Science 9, Unit 5: Chemical Properties and Changes; Science 10, Unit 1: Energy from the Sun and on Science 10, Unit 3: Energy and Matter in Chemical Change. It provides students with a foundation for the study of stoichiometry and bonding in Chemistry 20 and electrochemistry, acids and bases in Chemistry 30.

The three **major concepts** developed in this unit are:

- solutions are homogeneous mixtures of pure substances
- acids and bases have an effect on aqueous *systems*
- a model of the gaseous state of *matter* provides insight into molecular behaviour.

In this unit, *students will develop* an ability to use the **skills and thinking processes** associated with the practice of science, emphasizing:

- initiating and planning
- collecting and recording data according to safety and environmental considerations
- organizing and communicating data

- evaluating the design of investigations into the properties of and *changes to matter*.

The STS connections in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the functioning of products or processes based on scientific principles
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- develop a questioning attitude and a desire to understand more about *matter*
- appreciate that scientific evidence is the foundation for generalizations and explanations about *matter*
- develop an awareness of the importance of water as a medium for chemical *change*
- value the need for safe handling and disposal of chemicals
- respect the usefulness of models and theories that are used to explain natural phenomena relating to the behaviour of gases
- develop an interest in the role of solutions, acids, bases and gases in daily life
- appreciate that our understanding of *matter* has been enhanced by the evidence obtained from the application of technology, particularly instruments for making measurements and managing data.

MAJOR CONCEPT	KNOWLEDGE
1. Solutions are homogeneous mixtures of pure substances.	<i>Students should be able to demonstrate an understanding that:</i>
	● the composition of solutions can be accurately described, by extending from Science 8, Unit 1, and Science 10, Unit 1 and Unit 3, the meaning of solute, solvent, dissolving, solution, solubility and the properties of water, and by: ● providing examples, from living and nonliving systems, of how dissolving substances in water is often a prerequisite for chemical change ● differentiating between electrolytes and nonelectrolytes ● defining concentration in terms of molarity (moles per litre of solution) ● using simple calculations to show different ways of expressing concentration; e.g., per cent by mass and volume, parts per million (ppm) ● outlining the steps required to prepare a solution and a dilution of a solution ● describing an equilibrium system in a saturated solution in terms of equal rates of dissolving and crystallization.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- using a simple conductivity apparatus to perform an experiment to identify solutions
- using a balance and volumetric glassware to prepare solutions of specified concentration
- performing an experiment to determine the identity of an ion, using simple qualitative tests, including solution colour, flame tests and solubility
- writing dissociation/ionization equations for dissolved strong acids and ionic compounds
- calculating, from empirical data, the concentration of solutions in moles per litre of solution and determining mass or volume from such concentrations
- calculating, from empirical data, the concentration of diluted solutions, and the quantities of a solution and water to use when diluting
- using empirical data and dissociation equations to calculate the concentration of ions in a solution.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding solutions and their significance in living and nonliving systems; and ways of expressing and calculating concentration; and preparing solutions, using qualitative tests to identify solutions and ions in solution, within the context of:

- providing examples of how solutions and solution concentrations are applied in products and processes, in scientific studies and in daily life, and comparing the ways in which concentrations of solutions are expressed in the chemistry laboratory, in household products and in environmental studies

OR

- explaining the role of concentration in risk/benefit analysis and the significance of biological magnification in increasing the concentration of substances within ecosystems in terms of protecting the environment from harm to ensure quality of life for future generations

OR

- evaluating the risk involved in safe handling, storing and disposing of solutions in common use in the laboratory and in the home

OR

- investigating the application of the scientific principles of qualitative analysis in the practice of chemistry; e.g., careers in forensic science

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. Acids and bases have an effect on aqueous *systems*.

- acids and bases affect the chemistry of aqueous systems, by extending from Science 9, Unit 5, and Science 10, Unit 3, the properties, formulas and names of acids and bases, and by:
 - defining acids and bases, ionization and neutralization, empirically and theoretically, based on Arrhenius' concepts
 - defining pH in terms of whole number powers of 10
 - describing the relationship between pH and hydrogen ion concentration; i.e., a change of 1 in the pH value is equivalent to a ten-fold change in the hydrogen ion concentration
 - calculating whole number pH values from hydrogen ion concentration and hydrogen ion concentration from whole number pH values.

SKILLS

STS CONNECTIONS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- using indicators, pH and conductivity to perform experiments to differentiate among acidic, basic and neutral solutions
- calculating concentrations of H^+ or OH^- for strong acids and bases
- constructing a table comparing pH and hydrogen ion concentration in order to illustrate that as the hydrogen ion concentration increases, the pH decreases.

- understanding that acids and bases affect the chemistry of aqueous systems by defining acids and bases, by differentiating among acidic, basic and neutral solutions, using simple tests, writing ionization equations, and calculating the concentrations of hydrogen and hydroxide ions in solution and pH, within the context of:

- providing examples of products and processes that use knowledge of acid and base chemistry; e.g., pulp and paper, car batteries, food preparation, cleaning aids

OR

- identifying some everyday products and processes that require knowledge of how to handle acids and bases; e.g., sulfuric acid in car batteries, never mixing bleach with household cleaners; treating accidental acid or base spills, using neutralization and dilution

OR

- assessing, qualitatively, the risks and benefits of transporting acidic and caustic substances in populated areas in terms of the need to protect the environment to ensure society's safety and quality of life for future generations

OR

- relating the concept of pH to its application in describing solutions encountered in everyday life and comparing the pH scale to others, like the Richter scale for measuring the intensity of earthquakes

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

3. A model of the gaseous state of *matter* provides insight into molecular behaviour.

- the behaviour of gases has been extensively described, and relationships quantified, by extending from Science 7, Unit 4, the concept of temperature and from Science 10, Unit 4, the kinetic molecular theory and how it accounts for the properties of solids, liquids and gases, and by:
 - performing calculations, using Boyle's and Charles' laws, and illustrating how they are related to the combined gas law
 - relating Boyle's, Charles' and Avogadro's laws to the ideal gas law
 - converting between the Celsius and Kelvin temperature scales and expressing atmospheric pressure in a variety of ways; e.g., mm of Hg, atm, kPa
 - performing calculations based on the ideal gas equation, $PV=nRT$, under a variety of conditions; e.g., standard temperature and pressure (STP), standard atmosphere, temperature and pressure (SATP)
 - describing the behaviour of ideal and real gases in terms of the kinetic molecular theory.

SKILLS

STS CONNECTIONS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- drawing and interpreting graphs of experimental data that relate pressure and temperature to gas volume
- designing and performing an experiment to illustrate the gas laws, which identify and control variables
- performing and evaluating an experiment to determine molar mass from gaseous volume
- using empirical data to do calculations based on the ideal gas law.

- understanding the behaviour of gases by relating the gas laws proposed by Boyle, Charles and Avogadro to the ideal gas law, describing the behaviour of real and ideal gases in terms of the kinetic molecular theory; and by drawing and interpreting graphs that relate pressure and temperature to gas volume; designing, performing and evaluating experiments to illustrate the gas laws, and carrying out calculations based on the gas laws, within the context of:

- providing examples of products and processes from daily life that illustrate the application of the properties of gases; e.g., breathing, olfaction, weather, scuba diving, ammonia fertilizer, internal combustion engine, steam turbine, hot air balloon, automobile air bag

OR

- describing, from a historical perspective, the central role of experimentation, and the development of technologies capable of precise measurement in the formulation of the gas laws

OR

- evaluating, in terms of the influence of the needs, interests and financial support of society on scientific and technological research, the advantages and disadvantages of using compressed gases as fuels; e.g., hydrogen, methane, propane

OR

- any other relevant context.

UNIT 2 QUANTITATIVE RELATIONSHIPS IN CHEMICAL CHANGES

OVERVIEW

Science Themes: *Change and Systems*

In Unit 2, students focus on chemical *change* and the quantitative relationships contained in the balanced chemical equation. Students are required to use mathematical manipulation and stoichiometric principles to predict quantities of substances consumed or produced in chemical reactions. This unit builds on Science 10, Unit 3: Energy and Matter in Chemical Change, and Chemistry 20, Unit 1: Matter as Solutions, Acids, Bases and Gases.

This unit provides students with a foundation for the study of quantitative relationships in thermochemical, electrochemical, and acid and base reactions in Chemistry 30.

The two major concepts developed in this unit are:

- balanced chemical equations indicate the quantitative relationships among reactants and products involved in chemical *changes*

- the relationships between amounts of reactants and products in chemical *changes* are used in quantitative analysis.

In this unit, *students will develop* an ability to use the **skills and thinking processes** associated with the practice of science, emphasizing:

- initiating and planning

- collecting and recording

- organizing and communicating

- analyzing data related to quantitative relationships in chemical *change*.

The STS connections in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the functioning of products or processes based on scientific principles
- the ways in which science advances technology and technology advances science.

ATTITUDES

Students will be encouraged to:

- develop a positive attitude toward mathematical and scientific process skills
- appreciate the importance of careful laboratory techniques and precise calculations for obtaining accurate results
- develop confidence in their ability to reason mathematically
- value the role of technology, such as calculators and balances in problem solving
- develop an awareness of the relationship between chemical principles and applications of chemistry
- appreciate the need for empirical evidence when interpreting observed phenomena.

MAJOR CONCEPT**KNOWLEDGE**

Students should be able to demonstrate an understanding that:

1. Balanced chemical equations indicate the quantitative relationships among reactants and products involved in chemical changes.

- the mole ratios in balanced chemical reaction equations provide quantitative information about the substances involved, by extending from Science 10, Unit 3, the balancing of equations and the meaning of molar mass, and by:
 - predicting the product(s) of a chemical reaction, based upon the reaction type
 - analyzing chemical equations in terms of atoms, molecules, ionic species and moles
 - using gravimetric, solutions and gas stoichiometry to predict quantities of products/reactants involved in chemical reactions
 - using estimation and unit analysis in stoichiometric calculations
 - explaining stoichiometric calculations, using chemical principles.

SKILLS

STS CONNECTIONS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- performing experiments to test the validity of assumptions contained in stoichiometric methods, by, for example, predicting reaction results, then measuring the amount of product obtained from a reaction, and calculating the per cent yield.
- understanding that balanced chemical equations indicate quantitative relationships between products and reactants by analyzing chemical equations, performing and explaining stoichiometric predictions; and by performing experiments to test the assumptions contained in stoichiometric methods, within the context of:
- analyzing, using stoichiometric and chemical principals, the chemical reactions involved in various industrial and commercial products and processes; e.g., fertilizers, production of sodium and chlorine in the Downs cell, Haber-Bosch production of ammonia, combustion of fuels, water treatment, inflation of automobile air bags

OR

- discussing the central role of experimental evidence and the way in which scientific theories may be supported, modified or refuted by, for example, citing Lavoisier's role in disputing the caloric theory

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. The relationships between amounts of reactants and products in chemical *changes* are used in quantitative analysis.

- stoichiometric methods are important in quantitative analysis, by:
 - differentiating between qualitative and quantitative analysis
 - using evidence from titration to determine the concentration of a solution
 - using evidence from precipitation reactions to determine the concentration of ions in solutions, using gravimetric procedures
 - identifying limiting species in chemical reactions, and calculating predicted and experimental yields
 - explaining quantitative analysis, using chemical principles; e.g., conservation of mass in a chemical change.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- using appropriate glassware and equipment to perform a titration experiment to determine the concentration of a solution
- performing and evaluating an experiment, based on a precipitation reaction, to determine the concentration of a solution
- designing, performing and evaluating an experiment based on methods, such as crystallization, filtration or titration, to determine the concentration of a solution.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding the relationships among amounts of reactants and products in chemical changes, limiting species, predicted and experimental yields; and by designing, performing and evaluating experiments and carrying out calculations based on quantitative analysis to determine the concentration of a solution, within the context of:

- explaining the interrelationship of science and technology, using examples of how stoichiometry is applied; e.g., industries use stoichiometric calculations to determine the amount of raw materials needed to produce products with a minimum of waste

OR

- describing industrial, commercial and household products and processes, and associated careers, that require a knowledge of quantitative analysis

OR

- evaluating the significance of specific by-products from industrial, commercial and household applications of chemical reactions in terms of using technology to improve per cent yield, decrease waste and reduce environmental impact; e.g., recovering $\text{SO}_2(\text{g})$ from smokestacks, installing catalytic afterburners on cars, finding alternatives to chlorine for disinfecting and bleaching

OR

- any other relevant context.

UNIT 3 CHEMICAL BONDING IN MATTER

OVERVIEW

Science Theme: *Matter*

The major focus of this unit is to relate theories about bonding to the properties of *matter* and to develop explanations and descriptions of structure and bonding through scientific models.

This unit builds on Science 10, Unit 3: Energy and Matter in Chemical Change, and units 1 and 2 of Chemistry 20. This unit provides an introduction to Chemistry 30, Unit 1: Thermochemical Changes, and Unit 2: Electrochemical Changes.

The **major concept** developed in this unit is:

- chemical bonding in *matter* results in the formation of compounds.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning
- collecting and recording
- analyzing
- connecting, synthesizing and integrating while investigating bonding in *matter*.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the inability of science to provide complete answers to all questions
- the functioning of products or processes based on scientific principles
- the limitations of scientific knowledge and technology.

ATTITUDES

Students will be encouraged to:

- develop curiosity about the nature of chemical bonding
- appreciate the usefulness of models and theories in helping to explain the structure and behaviour of *matter*
- value the need for safe handling and disposal of chemicals
- tolerate the uncertainty in explanations about the nature of *matter*
- appreciate the restricted nature of evidence when interpreting observed phenomena.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. Chemical bonding in *matter* results in the formation of compounds.

- theories about bonding propose that chemical bonds involve electron transfer or sharing, by extending from Science 10, Unit 3, the simple model of the atom, the organization of the periodic table and the differences in properties of ionic and covalent compounds, and by:
 - defining a chemical bond as resulting from the simultaneous attraction of electrons by two atomic nuclei
 - describing bonding as a continuum ranging from complete electron transfer to equal sharing of electrons
 - defining valence electron, electronegativity, electron pairing, ionic bond and covalent bond
 - determining the polarity of a molecule based on simple structural shapes and unequal charge distribution
 - explaining why formulas for ionic compounds refer to the simplest whole number ratio of ions that result in a net charge of zero, while the formulas for molecular compounds refer to the number of atoms of each constituent element
 - comparing intramolecular bonding with intermolecular forces, in terms of strength and species involved
 - explaining, in simple qualitative terms, the energy changes of bond breaking and bond formation and relating this to why some changes are exothermic while others are endothermic
 - describing the information contained in the activity series and how it was developed
 - defining oxidation as a loss of electrons and reduction as a gain of electrons
 - relating the terms oxidation and reduction to bonds forming between metals and nonmetals; e.g., corrosion.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- building models depicting the structure of simple covalent molecules and ionic solids
- using the periodic table as a tool for predicting the formation of ionic and molecular compounds
- writing half-reactions for the formation of simple ionic compounds, showing oxidation of metals and reduction of nonmetals; then balancing for charge and combining into a single equation; e.g.,

$$2\text{Na(s)} \rightarrow 2\text{Na}^+ + 2\text{e}^-$$

$$\text{Cl}_{2(\text{g})} + 2\text{e}^- \rightarrow 2\text{Cl}^-$$

$$2\text{Na(s)} + \text{Cl}_{2(\text{g})} \rightarrow 2\text{NaCl(s)}$$
- designing and performing an experiment to investigate the reactivity of various metals with water, oxygen and dilute acid, to develop an activity series
- using data contained in the periodic table, and the activity series to predict bonding and electron transfer between elements
- drawing electron dot diagrams of atoms and molecules, writing structural formulas for compounds, and using Lewis structures to predict bonding in simple molecules.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that chemical bonds involve electron transfer or sharing, by comparing and contrasting intermolecular and intramolecular bonding; building models of compounds, using the periodic table and activity series to predict bonding; designing and performing an experiment to investigate the activity series of metals, and drawing electron dot diagrams and Lewis structures, within the context of:

OR
- analyzing the functioning of everyday products and processes in which ionic and covalent compounds are significant; for example, investigating the composition of household products, combustion reactions and life processes
- relating the chemical principles embedded in bonding theories, oxidation and reduction, and the activity series to terms such as "precious" metal, rusting, stability and reactivity

OR
- outlining the limitations of bonding theories by; for example, investigating bonding in metals and ceramics, and investigating the concept of resonance

OR
- describing the central role of experimental evidence in the accumulation of knowledge by relating the properties; e.g., melting and boiling points, solubility, density and viscosity, of common substances to their predicted intermolecular and intramolecular bonding

OR
- interrelating the applications and properties of modern materials, such as semiconductors, ceramics and composites, explaining how science and technology interact in the production and distribution of useful materials; and explaining the influence of the needs, interests and financial support of society on scientific and technological research

OR
- any other relevant context.

UNIT 4

THE DIVERSITY OF MATTER: AN INTRODUCTION TO ORGANIC CHEMISTRY

OVERVIEW

Science Themes: *Change, Diversity and Matter*

In this unit, students learn more about the *diversity* of *matter* from specific examples of organic compounds. They are introduced to the chemical and physical properties of organic compounds, the general nomenclature and formulas for hydrocarbon categories, their significant derivatives and reactions. Another theme of the unit is *change* as it relates to chemical reactions involving organic compounds in living and nonliving systems.

This unit builds on Science 9, Unit 5: Chemical Properties and Changes; Science 10, Unit 3: Energy and Matter in Chemical Change; and Chemistry 20, Unit 3: Chemical Bonding in Matter. The unit prepares students for the integrated approach to organic and inorganic chemistry that is taken in Chemistry 30.

The two **major concepts** developed in this unit are:

- organic compounds are a common form of *matter*
- the chemical *changes* of organic compounds are many and *diverse*.

In this unit, *students will develop* an ability to use the **skills and thinking processes** associated with the practice of science, emphasizing:

- initiating and planning
- organizing and communicating
- connecting, synthesizing and integrating in the investigation of organic compounds and their reactions.

The **STS connections** in this unit illustrate:

- the functioning of products or processes based on scientific principles
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- develop an appreciation of the diversity of organic compounds and their significance to daily life
- appreciate that science and technology provide many useful products
- value the need for safe handling and disposal of chemicals
- develop an awareness that, as a result of chemistry, synthetic compounds of great benefit to society have been produced
- develop an awareness of the need for open-mindedness in evaluating environmental issues
- respect the contributions and limitations of scientific and technological knowledge to societal decision making.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. Organic compounds are a common form of *matter*.

- organic compounds have distinguishing characteristics, by:

- comparing organic and inorganic compounds in terms of the presence of carbon, bonding and related properties, and natural sources
- describing the composition and structural formulas for aliphatic (including cyclic) and aromatic hydrocarbons
- providing names and formulas for examples of the organic compounds described above
- defining and giving examples of structural isomerism
- identifying alcohols, aldehydes, ketones, carboxylic acids, halogenated hydrocarbons, amines, amides and esters from their IUPAC names and the functional groups in their structural formulas.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- using safe substances and procedures to perform an experiment to investigate the physical and chemical properties of representative examples of organic compounds
- gathering data to compare the properties of a pair of organic isomers
- building molecular models depicting the structures of simple organic compounds.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that organic compounds have distinguishing characteristics by comparing them with inorganic compounds, describing the composition of and providing names and structural formulas for various hydrocarbons and their derivatives; and by investigating the physical and chemical properties of representative examples of organic compounds and building models depicting the structures of simple examples, within the context of:

- comparing examples of organic and inorganic compounds and where they are found and how they are used in products and processes common to everyday life

OR

- explaining different conventions of nomenclature in a historical and cultural context

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. The chemical *changes* of organic compounds are many and *diverse*.

- organic compounds undergo a variety of chemical reactions, by:
 - defining and giving examples of addition, substitution, elimination, esterification and combustion reactions of hydrocarbons
 - writing and balancing chemical equations for the reactions described above
 - defining, outlining structures, and providing examples of monomers, polymers and polymerization in living and nonliving systems; e.g., plastics, carbohydrates, proteins
 - comparing reactions of organic compounds in living and nonliving systems; e.g., the combustion of fuels and the oxidation of carbohydrates
 - comparing hydrocarbon cracking and reforming.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- building models depicting polymerization
- synthesizing an organic compound; e.g., an alcohol, an ester, a polymer, a soap.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that organic compounds undergo a variety of chemical changes by defining, giving examples of and writing chemical equations for various reactions; and by synthesizing an organic compound in the laboratory and building models to depict polymerization, within the context of:

- analyzing common polymers in terms of chemical composition and structure; e.g., paper, plastics, fibres, foods, found in the home, school and community

OR

- describing the petrochemical industry in Alberta and investigating career opportunities related to organic chemistry

OR

- assessing the positive and negative effects of synthetically produced organic compounds, recognizing that the development of these products has played a major role in our quality of life and standard of living but that a practical solution to related social and environmental problems often requires a compromise between competing priorities

OR

- any other relevant context.

CHEMISTRY 30

UNIT 1 THERMOCHEMICAL CHANGES

OVERVIEW

Science Themes: *Change, Energy and Systems*

In this unit, students study *energy* as it relates to physical, chemical and nuclear *changes* and quantify the energy involved in thermochemical *systems*.

This unit builds on Science 9, Unit 3: Heat Energy: Transfer and Conservation; Science 10, Unit 1: Energy from the Sun, Unit 3: Energy and Matter in Chemical Change, and Unit 4: Change and Energy; and Chemistry 20, Unit 2: Quantitative Relationships in Chemical Changes. This unit prepares students for post-secondary studies in related areas.

The major concept developed in this unit is:

there are *energy changes* associated with *changes to matter*.

In this unit, *students will develop* an ability to use the skills and *thinking processes* associated with the practice of science, emphasizing:

initiating and planning

collecting and recording

organizing and communicating

analyzing

connecting, synthesizing and integrating

evaluating investigations of *energy changes*.

The STS connections in this unit illustrate:

the use of technology to solve practical problems

the influence of the needs, interests and financial support of society on scientific and technological research

- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- develop an interest in the *energy* transformations happening around them
- appreciate the usefulness of computational competence and problem-solving skills as they relate to *energy*
- value the need for accuracy and precision in data collection related to *energy*
- develop a sense of responsibility toward the use of *energy*
- develop an interest in global *energy* issues and the effectiveness of local activities in contributing to the solution of problems related to *energy*
- appreciate the need to balance long-term *energy* and environmental objectives with various societal needs
- appreciate the significance and meaning of various solutions to a problem.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. There are *energy changes* associated with *changes to matter*.

- energy changes can be measured and quantified, by extending from Science 10, Unit 1 and Unit 4, the law of conservation of energy, the laws of thermodynamics, definitions for potential and kinetic energy, heat of fusion and calculations involving temperature and phase changes in water, based on $Q = mc\Delta T$, as well as extending from Chemistry 20, Unit 3, the meaning of bond dissociation energy, exothermic and endothermic change, and by:
 - explaining what is meant by the energy change of a system in terms of heating and cooling, thermal equilibrium, temperature change, phase change, forces between particles, particle movement and heat content
 - writing balanced reaction equations that include the energy change
 - using and interpreting change in enthalpy (ΔH) notation for communicating energy changes
 - explaining that catalysts provide an alternative pathway for chemical changes without affecting the net amount of energy produced or absorbed
 - defining molar enthalpy, including the heats of phase, chemical and nuclear change
 - using a standard heats of formation table to predict heat of reaction for a chemical change
 - using Hess's law to derive equations for energy changes
 - explaining how energy stored as potential energy in the chemical bonds of fossil fuels originates in the Sun and is converted by the process of photosynthesis in living plants represented simply as:
 $6\text{CO}_{2(g)} + 6\text{H}_2\text{O}_{(l)} \rightarrow \text{C}_6\text{H}_{12}\text{O}_{6(s)} + 6\text{O}_{2(g)}$
 - comparing cellular respiration represented by the simple equation: $\text{C}_6\text{H}_{12}\text{O}_{6(s)} + 6\text{O}_{2(g)} \rightarrow 6\text{CO}_{2(g)} + 6\text{H}_2\text{O}_{(l)}$ to the combustion of fuels
 - comparing phase, chemical and nuclear changes in terms of the magnitudes of the energy involved
 - providing simple qualitative explanations based on intermolecular forces, chemical bonds and nuclear forces for the energy changes that occur during phase, chemical and nuclear changes to matter
 - recognizing nuclear fission and fusion reactions.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- drawing and interpreting energy diagrams based on experimental data; e.g., heating curves and potential energy graphs for phase, chemical and nuclear changes
- performing and evaluating experiments to determine the molar enthalpies of physical and chemical changes to matter
- performing calculations based on empirical data gathered from experiments demonstrating energy changes associated with chemical and physical changes to matter
- designing an experimental procedure to compare the molar enthalpy of two or more fuels
- designing and constructing a heating device, and calculating its efficiency.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that the energy changes associated with changes to matter can be measured and quantified by explaining the energy change of a system; providing simple explanations for energy changes in phase, chemical and nuclear changes; performing calculations related to physical and chemical changes to matter; and by drawing and interpreting energy diagrams; and designing, performing and evaluating experiments to determine molar enthalpies and energy efficiency, within the context of:

- providing examples of their personal reliance on the chemical potential energy of matter; e.g., of fuels and identifying and evaluating ways of using energy more efficiently in the home and community in order to use our natural resources judiciously to ensure adequate supplies for future generations

OR

- providing examples of how catalysts play a role in many important chemical and biochemical processes; e.g., enzymes in cell processes, catalysts in reducing air pollution

OR

- illustrating the economic importance of fossil fuels, with examples from the petroleum and petrochemical industries in Alberta; analyzing, using chemical principles, the refining of hydrocarbons; and investigating careers related to the energy industry

OR

- evaluating different fuels from the perspective of economic and environmental impact and researching and analyzing alternative energy sources, in terms of the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations

OR

- assessing, qualitatively, the risks and benefits of relying on fossil fuels or nuclear reactions as energy sources, considering the limitations of scientific knowledge and technology in societal decision making

OR

- any other relevant context.

UNIT 2 ELECTROCHEMICAL CHANGES

OVERVIEW

Science Themes: *Change, Energy, Matter and Systems*

In this unit, students study electrochemical *changes*, analyzing the *matter* and *energy changes* within a *system*.

This unit builds on Science 9, Unit 4: Electromagnetic Systems; Science 10, Unit 3: Energy and Matter in Chemical Change; Chemistry 20, Unit 2: Quantitative Relationships in Chemical Changes, and Unit 3: Chemical Bonding in Matter. This unit prepares students for post-secondary studies in related areas.

The two **major concepts** developed in this unit are:

- many chemical *changes* involve the transfer of electrons
- *energy* is involved in electrochemical *changes*.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning
- collecting and recording
- organizing and communicating
- analyzing
- connecting, synthesizing and integrating
- evaluating investigations of electrochemical *change*.

The **STS connections** in this unit illustrate:

- the functioning of products or processes based on scientific principles
- the ways in which science advances technology and technology advances science

- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- develop an interest in oxidation-reduction reactions that occur in everyday life
- appreciate the creativity and perseverance required to develop workable solutions to problems
- develop a willingness to try various problem-solving strategies, and risk being wrong
- value the contributions of the technological innovations of electrochemistry to quality of life
- develop an awareness that the application of technology by human societies can have beneficial and harmful effects on biological *systems*
- appreciate the multi-dimensional nature of science, technology and society issues.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. Many chemical *changes* involve the transfer of electrons.

- oxidation-reduction reactions involve a transfer of electrons, by extending from Chemistry 20, Unit 3, the meanings for electronegativity, oxidation-reduction and the activity series, and by:
 - defining the terms: oxidizing agent, reducing agent, oxidation number, half-reaction, auto-oxidation (disproportionation)
 - differentiating between oxidation-reduction reactions and other reactions that do not involve oxidation-reduction by identifying half-reactions and changes in oxidation number
 - describing oxidation-reduction in simple biochemical processes; e.g., cellular respiration of glucose to carbon dioxide, $\text{C}_6\text{H}_{12}\text{O}_{6(\text{s})} + 6\text{O}_{2(\text{g})} \rightarrow 6\text{CO}_{2(\text{g})} + 6\text{H}_2\text{O}_{(\text{l})}$; photosynthesis in green plants, $6\text{CO}_{2(\text{g})} + 6\text{H}_2\text{O}_{(\text{g})} \rightarrow \text{C}_6\text{H}_{12}\text{O}_{6(\text{s})} + 6\text{O}_{2(\text{g})}$
 - identifying electron transfer, oxidizing agents and reducing agents in oxidation-reduction reactions
 - writing and balancing equations for oxidation-reduction reactions:
 - using half-reaction equations obtained from a standard reduction potential table
 - developing simple half-reaction equations from information provided about oxidation-reduction changes
 - assigning oxidation numbers to the species undergoing chemical change
 - comparing oxidation-reduction reactions in living and nonliving systems.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- comparing the relative strengths of oxidizing and reducing agents from empirical data
- designing, performing then evaluating an experiment for deriving a simple reduction table
- selecting the appropriate equipment, and using it correctly, to perform an oxidation-reduction titration experiment
- performing calculations to determine quantities of substances involved in oxidation-reduction reactions by using data from titration experiments.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that many chemical changes involve a transfer of electrons by defining terms related to oxidation-reduction; identifying, writing and balancing equations for oxidation-reduction reactions, calculating unknown quantities from oxidation-reduction titration reactions; and by designing, performing and evaluating experiments for deriving a simple reduction table and testing predictions about oxidation-reduction, within the context of:

- analyzing, as an example of the functioning of products and processes based on scientific principles, oxidation-reduction reactions that occur in everyday life; e.g., corrosion, metallurgy, respiration, photosynthesis; identifying half-reactions, oxidizing and reducing agents

OR

- analyzing, as an example of the functioning of products and processes based on scientific principles, oxidation-reduction reactions used in industry and commercially; e.g., pulp and paper and textile bleaching, water treatment, food processing; identifying half-reactions, oxidizing and reducing agents

OR

- investigating the use of technology to solve practical problems related to corrosion

OR

- relating oxidation-reduction reactions to global environmental problems, such as the production of greenhouse gases and acid rain

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. *Energy is involved in electrochemical changes.*

- electrochemical cells operate on the energy of spontaneous oxidation-reduction reactions, while electrolytic cells require electrical energy to cause nonspontaneous oxidation-reduction reactions to occur, by:
 - defining and identifying, on a diagram of electrochemical and electrolytic cells, the following: anode, cathode, anion, cation; as well as salt bridge/porous cup and external circuit for the former and power supply for the latter
 - predicting and writing balanced equations for reactions at the cathode and the anode of electrochemical and electrolytic cells recognizing that predictions and observations do not always concur; e.g., the production of chlorine gas from the electrolysis of brine
 - identifying, on a diagram of electrochemical and electrolytic cells, the flow of electrons, the migration of cations and anions, mass and colour changes, formation of gases, and precipitates, at the electrodes
 - defining standard reduction potential and explaining how the values are all relative to $E^{\circ} = 0.00 \text{ V}$ set for the standard hydrogen electrode
 - calculating standard cell potential values for oxidation-reduction reactions
 - predicting the spontaneity or nonspontaneity of oxidation-reduction reactions on the basis of calculated standard cell potential values and relative positions of half-reaction equations on a standard reduction potential table
 - performing calculations to determine quantities of mass, volume, concentration, current and time in single electrochemical and single electrolytic cells.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- constructing, observing and describing an electrolytic cell, comparing predictions and observations
- designing, constructing and measuring the standard cell potential of an electrochemical cell, comparing predictions and observations
- evaluating experimental designs for electrochemical and electrolytic cells, identifying limitations and suggesting improvements and alternatives
- using a standard reduction potential table as a tool in predicting the spontaneity of oxidation-reduction reactions and the products
- performing an experiment to test predictions about oxidation-reduction reactions with regard to spontaneity, products and standard cell potential values.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding electrochemical and electrolytic cells by identifying and defining their important features on a diagram; predicting and writing balanced equations for reactions that occur at the cathode and anode, and performing calculations to determine quantities of products formed in them; and by designing, constructing, observing and describing electrolytic and electrochemical cells, within the context of:

- analyzing the ways in which science advances technology and technology advances science in the applications of electrochemical and electrolytic cells; e.g., batteries, electroplating industries, refining metals from their ores, and sanitizing swimming pools

OR

- comparing and contrasting the energy costs of refining metals from their ores with recycling metals, and outlining the process by which commonly used metal-based products; e.g., aluminum or "tin" cans, are recycled in their community as an example of society taking the responsibility to protect the environment and use natural resources judiciously to ensure quality of life for future generations

OR

- assessing the economic importance of batteries to modern society, predicting their future prominence, for example, in transportation; investigating the issue of disposing of used batteries, and proposing alternative solutions to this problem

OR

- any other relevant context.

UNIT 3 EQUILIBRIUM, ACIDS AND BASES IN CHEMICAL CHANGES

OVERVIEW

Science Themes: *Change, Equilibrium and Systems*

In this unit, the concept of *equilibrium* is expanded to quantitative treatment in reaction *systems* involving ideal gases and acid and base solutions. Students apply stoichiometric methods to titration experiments, further explore indicators and are introduced to buffer *systems*.

This unit builds on Science 8, Unit 1: Solutions and Substances; Science 9, Unit 5: Chemical Properties and Changes; Science 10, Unit 3: Energy and Matter in Chemical Change; Chemistry 20, Unit 1: Matter in Solutions, Acids, Bases and Gases, and Unit 2: Quantitative Relationships in Chemical Changes. This unit prepares students for post-secondary studies in related areas.

The three **major concepts** developed in this unit are:

• there is a balance of opposing reactions in chemical *equilibrium systems*

• acid and base *systems* are quantitatively and qualitatively described

• acid-base chemistry involves proton transfer.

In this unit, *students will develop* an ability to use the **skills and thinking processes** associated with the practice of science, emphasizing:

- initiating and planning
- collecting and recording
- organizing and communicating
- analyzing
- connecting, synthesizing and integrating
- evaluating investigations of *equilibrium*, acids and bases.

The STS connections in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the functioning of products or processes based on scientific principles
- the limitations of scientific knowledge and technology
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- appreciate the usefulness of the mathematical model in describing chemical *equilibrium*
- value the role of precise observation and careful experimentation in learning about the chemistry of acids and bases
- tolerate the uncertainty involved in providing theoretical definitions for acids, bases and *equilibrium*
- value the need for safe handling, storage and disposal of chemicals
- appreciate the complexity of environmental problems, such as acid deposition, that have no simple solution
- foster intellectual honesty, open-mindedness and objectivity when assessing environmental effects caused by chemical *change*.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. There is a balance of opposing reactions in chemical *equilibrium systems*.

- chemical reactions involving gases, acids and bases can be described as dynamic equilibrium systems, by extending from Chemistry 20, the model for equilibrium in a saturated solution, and by:
 - stating the criteria that apply to a system at equilibrium; e.g., closed system, constancy of properties, evidence of reversibility, equal rates of forward and reverse reactions
 - writing and interpreting chemical reaction equations for chemical systems at equilibrium
 - relating the reversibility of reactions in electrochemical cells to equilibrium
 - calculating equilibrium constants/concentrations for simple homogeneous chemical systems when:
 - concentrations at equilibrium are known
 - initial concentrations and one equilibrium concentration are known
 - the equilibrium constant and one equilibrium concentration are known
 - predicting whether or not reactants or products are favoured in a reversible reaction, on the basis of the magnitude of the equilibrium constant
 - using Le Chatelier's principle to predict, qualitatively, shifts in equilibrium caused by changes in temperature, pressure, volume or concentration
 - explaining that catalysts do not affect the concentrations at equilibrium, only the time it takes for a system to reach equilibrium.

SKILLS

STS CONNECTIONS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- identifying variables and performing an experiment to test, qualitatively, predictions of equilibrium shifts.

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that many chemical reactions can be described as dynamic equilibrium systems by stating the criteria that identify them; writing equations, calculating equilibrium constants and concentrations for chemical systems at equilibrium, and by designing and performing experiments to analyze, qualitatively, shifts in equilibrium, within the context of:

- applying equilibrium principles to analyze everyday phenomena; e.g., the higher concentration of red blood cells in the circulatory systems of people living at high altitudes; carbon dioxide gas escaping from an open bottle of pop; the precipitation of limestone in caves; the rapid corrosion of metals in the presence of an acid; the role of oceans in the carbon cycle

OR

- analyzing industrial processes, such as the Haber-Bosch process, for producing ammonia, and the Solvay process for making sodium carbonate, on the basis of equilibrium principles

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. Acid and base *systems* are quantitatively and qualitatively described.

- acid and base systems are quantitatively and qualitatively described in a variety of ways, by extending from Chemistry 20, the definitions for acids, bases and pH, and by:
 - explaining the pH/pOH scale in terms of logarithms
 - defining K_w , K_a and K_b
 - calculating $H_3O^+_{(aq)}$ and $OH^-_{(aq)}$ concentrations, pH and pOH for solutions, using the ionization constant for water, K_w
 - predicting, qualitatively, changes in pH and pOH when a solution is diluted
 - differentiating between strength and concentration in acids and bases on the basis of empirical properties
 - comparing strong and weak acids and strong and weak bases, using equilibrium principles
 - performing calculations to determine any of pH, pOH, $[H_3O^+_{(aq)}]$, $[OH^-_{(aq)}]$, K_a , or K_b from the masses of solute, volumes and concentrations of solutions
 - performing calculations to determine masses of solutes, volumes or concentrations of solutions from pH, pOH, $[H_3O^+_{(aq)}]$, $[OH^-_{(aq)}]$, K_a and K_b .

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- designing and performing an experiment to differentiate among strong and weak acids and bases and a variety of neutral solutions
- calculating K_a and K_b from provided empirical data.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that acid and base systems are quantitatively described, using pH, pOH, $[H_3O^+_{(aq)}]$, $[OH^-_{(aq)}]$, K_w , K_a , K_b , and concentration; and by performing calculations to determine any of the above from empirical data, and differentiating among strong and weak acids and bases and other solutions, within the context of:

- describing the significance of pH in the formulation of various products, in the maintenance of viable aquatic and terrestrial environments, and in the body fluids of living systems; and understanding the importance of chemical principles to explain the functioning of products and processes

OR

- tracing, from a historical perspective, the development of the pH scale as an example of the way scientists have always strived to improve communication

OR

- explaining the significance of strength and concentration in chemical spills, in transport of dangerous goods, and in acid deposition; and discussing the need for society and individuals to protect the environment for future generations

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

3. Acid-base chemistry involves proton transfer.

- Brønsted-Lowry acid-base reactions involve proton transfer, by extending from Chemistry 20, the Arrhenius definitions for acids and bases and neutralization, and by:
 - writing and interpreting chemical reaction equations illustrating the Brønsted-Lowry definition of acids and bases and neutralization
 - identifying conjugate pairs of Brønsted-Lowry acids and bases in chemical reaction equations
 - defining and describing indicators and explaining their colour changes in terms of an equilibrium shift
 - describing examples of substances that can act as either proton donors or proton acceptors
 - describing examples of substances that can accept or donate more than one proton, and writing and interpreting related chemical equations
 - performing calculations related to quantitative reactions between acids and bases, including excess reagents in strong acid-strong base combinations
 - differentiating between indicator end point and equivalence point
 - explaining how buffers maintain a relatively constant pH when small amounts of acid, base or solvent are added to an aqueous system
 - providing examples of buffers that operate in living systems; e.g., in blood.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- predicting the most likely acid-base reaction, using tables of relative acid-base strength
- designing and performing an experiment to determine the properties of inorganic and organic acids
- standardizing an acid or base solution, using primary standards
- performing a titration experiment and related calculations to determine the concentration of an acid or base solution
- using a pH meter and laboratory glassware related to titrations
- using indicators to determine the approximate pH of an acid or base solution
- drawing and interpreting titration curve graphs, using data from titration experiments involving acids and bases in various combinations, including:
 - a strong acid with a strong base
 - a strong acid with a weak base
 - a weak acid with a strong base
 - a strong acid with a polybasic species
 - a strong base with a polyprotic species
- designing, performing and evaluating an experiment to test buffer action.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding the Brønsted-Lowry definition of acids and bases by analyzing, predicting and writing chemical equations for acid and base reactions; explaining indicators, buffers and titration; performing calculations related to reactions between strong acids and strong bases; and by designing, performing and evaluating experiments to investigate acids, bases and buffer action; performing a titration experiment, and drawing and interpreting titration curve graphs, within the context of:

- explaining, from a historical perspective, the limitations of acid-base concepts in explaining observed phenomena and the ways in which proposed theories for acids and bases have been supported, modified or refuted

OR

- explaining, using chemical principles, the formation of acid deposition, describing the environmental impact and the measures being taken by industries to reduce emissions, and evaluating the problem of acid deposition, recognizing that a practical solution is limited by current scientific knowledge and technology and may require a compromise between competing priorities

OR

- analyzing, on the basis of chemical principles, the application of acids and bases indicators and buffers; e.g., in processing and storage of food, in pharmaceuticals, in cleaning aids, fertilizers and other industrial products

OR

- any other relevant context.

D. BASIC LEARNING RESOURCES

Chemistry 20 and Chemistry 30

Print

Jenkins, Frank et al. *Nelson Chemistry*.
Scarborough, ON: Nelson Canada, 1993.

ISBN 0176038639

Wilbraham, Antony C. et al. *Addison-Wesley Chemistry*. Canadian edition/International System of Units (SI) edition. Don Mills, ON: Addison-Wesley Publishers Limited, 1993.

ISBN 0201602024

Nonprint

The Living Textbook Series: Physical Science.

- *Chemistry at Work*, 1991
[laser disc correlated to *Addison-Wesley Chemistry* basic text]
- *Cosmic Chemistry*, 1990
 - : *Safety, Atomic Structure, Nuclear Chemistry, Physical Properties*
 - : *Chemical Changes, Metals, Nonmetals*
 - : *Acids and Bases, Redox and Electrochemistry*
 - : *Consumer Chemistry, The Stills Collection, Environmental Chemistry, Cosmic Chemistry*[4 laser discs correlated to both basic texts]
- *Principles of Physical Science*, 1990
 - : *Matter, Motion and Forces*
 - : *Waves, Electricity and Magnetism*[2 laser discs]

DATE DUE SLIP

[illegible]

University of Alberta Library



0 1620 0134 3621